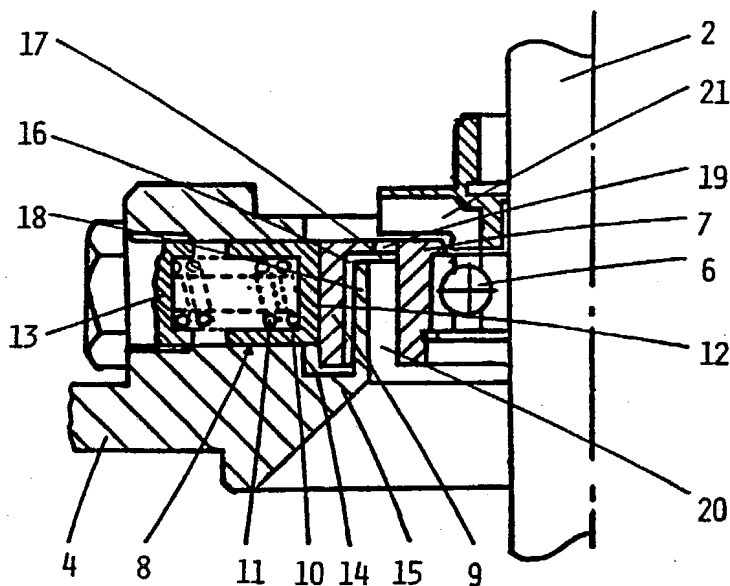




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(54) Title: CENTRIFUGAL SEPARATOR WITH A LUBRICATED DAMPING DEVICE



(57) Abstract

Centrifugal separator, the rotor (1) of which is supported and driven by a shaft (2). The shaft (2) is supported in a frame (4) by means of a bearing (6), which is arranged in a bearing housing (7). The bearing housing (7) bears against the frame (4) via a damping device (8) comprising a first element (9), which follows the oscillating movements of the shaft (2), at least one second element (10), which is arranged movable relative to the frame and at least one elastical element (11), which presses the second element (10) radially inwards against the first element (9) at the contact area (12). In order to provide a centrifugal separator with a damping device, which during operation gives rise to a low and constant generation of heat, the centrifugal separator is designed with a device (15), which forms a bowl (14). The bowl (14) has an upwards directed opening (16) and is so located at the first and second element (9, 10) that at least a part of the contact area (12) is located in the bowl (14).

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Centrifugal separator with a lubricated damping device

The present invention concerns a centrifugal separator, the rotor of which is supported by a during operation oscillating vertical driving shaft, which is rotatably supported in a frame by means of at least one bearing arranged in a non-rotatable bearing housing, which is arranged to bear against the frame via a device, damping the oscillating movements of the shaft, the damping device comprising at least one first element, which is arranged to follow the oscillating movements of the shaft, at least one non-rotatable second element arranged movable relative to the frame towards the first element, and at least one elastic element arranged to press the second element radially inwards against the first element to create friction in the contact area between the first and the second element upon oscillation of the shaft, means being arranged to bring oil to flow around the damping device. Often the oil is brought to flow around the device by means of oil containing gas circulating around the same.

A known centrifugal separator of this kind is shown in US 2 848 468. In many applications for such centrifugal separators the rotor is driven at a number of revolutions, which exceeds the lowest critical number of revolutions at which it and the driving shaft tend to come into a point of self-oscillation. In order to make it possible, for instance upon start, to pass the critical number of revolutions with a rotor, which has a calculated maximum unbalance, a damping device has to be so dimensioned that it is able to damp the arising oscillations so that these upon this passage do not exceed permitted limits. Determining for these limits might be for instance the existing gap between rotor parts and stationary parts of the centrifugal separator located nearby or the strength of rotor parts therein. The main damping is taken place by the friction in the contact area between the first and the second element, which the

relative movement between them gives rise to, the oscillation energy being transformed into frictional heat. In order to obtain sufficient damping upon passage of the critical number of revolutions a certain pre-stress might be necessary of the generally stiff elastical element, whereby the contact pressure in said contact area is increased.

A problem in this connection is that the generated frictional heat is conducted from the first element to the bearing, whereby the operational temperature of the bearing is increased and the life of the bearing is shortened. During normal operation at a number of revolutions, which exceeds the critical number of revolutions, there is no need for damping since the oscillations, which then occur are stable and do not have any damaging amplitude. However, by the friction in this contact area, these oscillations generate a frictional heat, which continuously is transferred to the bearing and besides is an energy loss.

The contact surfaces between the first and the second element usually are located in a part of the centrifugal separator, in which a heavy circulation of air prevails and in a very oil rich environment. The limited amount of oil present between the contact areas, is then exposed for a very high temperature and a pressure, which means that it creates a layer of coke on the contact surfaces. This layer gradually increases the coefficient of friction between the contact surfaces, whereby the damping and the generated frictional heat, which are transferred to the bearing, increase.

The object of the present invention is to accomplish a centrifugal separator, the oscillating movements of which during passage of the critical number of revolutions is damped safely by means of a damping device, in which during operation a low and essentially constant generation of heat occurs.

According to the invention this can be accomplished by providing a centrifugal separator of the initially described kind with a device forming a bowl, which has an upwards directed opening and is so located at the first and the second element that at least  
5 a part of the contact area is located in the bowl.

In a centrifugal separator according to the invention a limitation is obtained of the amount of oil entrained by the air flow directed away from the contact area. The amount of oil, which  
10 has deposited on the surfaces of different parts and is located nearby this area, hereby will be large. The relatively large amount of oil, which is located in the contact area, results in that an efficient lubrication of the contact surfaces between the first and the second element is obtained, whereby the above  
15 mentioned creation of coke layers on the same is prevented. Hereby the friction coefficient does not increase during operation and consequently the frictional heat generated and transferred to the bearing does not increase during operation.

20 In a preferred embodiment of the invention said device is formed by a part of the frame, the first element extending downwards through the opening in the bowl. The first element is formed by a part of the bearing housing, which surrounds the rotational axis of the rotor. Hereby the device, the bowl and the part of  
25 the first element, extending downwards through the opening in the bowl, suitably are annular and surround the rotational axis of the rotor.

In another preferred embodiment of the invention a recess is  
30 formed in the first element, which recess has an axial extension and is open axially downwards and in which recess said device extends axially upwards. In this embodiment it is suitable to form the recess and the device annular surrounding the rotational axis of the rotor. Hereby the heat transfer of the frictional  
35 heat to the bearing is also decreased, which frictional

heat in spite of all is generated during operation in the contact area between the first and the second element. This decrease of heat transfer is achieved partly by decreasing the heat conduction from the contact area to the bearing as a result  
5 of the reduced cross-sectional area of the heat conducting material and partly by decreasing the heat transfer by radiation.

In a third embodiment of the invention the first element is  
10 designed with one or more passages, extending through the first element and connecting its upper side to its lower side, the device together with the element forming a gap, which is arranged to transport a cooling medium through the same and the passage. By the fact that a flow path is arranged in this manner  
15 for a cooling medium, an efficient transport of heat away from the first element is made possible, which results in a decrease of the heat transfer from the element to the bearing.

In the following the invention will be described more closely  
20 with reference to the accompanying drawing, in which figure 1 shows an axial section through a part of a centrifugal separator according to the invention and figure 2 shows an enlarged part of figure 1.

25 The shown embodiment of a centrifugal separator according to the invention has a rotor 1, which is supported and is rotatable by means of a vertical shaft 2. The rotor is surrounded by a casing 3, which is fixedly connected to a frame 4 and has a bottom opening 5. The shaft 2 extends from the interior of the frame  
30 through the bottom opening 5 into the interior of the casing 3. At its upper end the shaft 2 is supported in a radial bearing 6. This bearing 6 is arranged in a bearing housing 7, which via a damping device 8 elastically bears radially against the frame 4.

The damping device 8 comprises at least one first element 9, which is fixedly connected to the bearing housing 7, a number of second elements 10 distributed around the circumference of the bearing housing 7, the second element 10 being arranged  
5 movable relative to the frame 4 and supporting against the first element 9, and a number of elastical elements 11. In the shown example said second elements 10 and the elastical elements 11 are arranged in radial grooves in the frame 4 so that every elastical element 11 presses a second element 10 belonging to it  
10 radially inwards against the first element 9 to create friction in a contact area 12. The elastical elements 11 are compressed radially between the second elements 10 and a stop 13 fixedly connected to the frame. The radial position of the stop 13 can be adjusted, whereby the pre-stress of the elastical element and  
15 thereby also the contact pressure in the contact area 12 between the first and the second element can be varied.

The contact area 12 between the first and the second element 9 and 10, respectively, is located at least partly in a bowl 14.  
20 The bowl 14 is formed by a device 15 and has an upwards directed opening 16. The contact area 12 is located at least partly in the bowl. In the shown example the device 15 consists of a part of the frame 4.

25 The first element 9 is formed by a part of the bearing housing 7 and extends axially through the opening 16 into the bowl 14. The second element 10 extends radially into the bowl 14 through the opening of the groove in the bowl 14. In the first element 9 a downwards open recess 17 is formed. Upwards in this recess 17  
30 said device 15 extends with a wall 18, which constitutes a radially inner part of the bowl 14.

Through the first element 9 a passage 19 is arranged, extending axially through the first element 9 and connecting its upper  
35 side to its lower side. Together with the first element 9 the

5 wall 18 forms a gap 20 for transport of a cooling medium through the same and the passage 19. Above the bearing housing 7 a fan wheel 21 is arranged fixedly connected to the shaft 2 for transport of a cooling and lubricating medium such as oil-containing air. This medium can be sucked up out of the interior of the frame 4 partly through the bearing 6 and partly through the gap 20 and the passage 19 and flow downwards through axial channels 22 in the frame 4 back to the interior of the frame 4.

10 During operation of a centrifugal separator according to the invention the fan wheel 21 sucks up oil-containing air from the interior of the frame 4 to the bearing 6 and the upper side of the damping device 8. Some of the oil drops entrained by the air flow deposit on the surfaces on the different parts, where-  
15 from they flow downwards towards the interior of the frame. Some of these oil drops then flow down into the bowl 14, in which the air flow is less. This means an increase of the amount of oil along the internal surfaces of the bowl 14. The contact area 12, which at least partly is located in the bowl 14, is thereby  
20 lubricated efficiently. The rest of the oil drops entrained in the air flow follow the air flow back to the interior of the frame 4 through the channels 22.

The during operation occurring oscillating movements of the rotor  
25 1 and the shaft 2, are taken up and damped by the damping device 8. In this the oscillation energy of the rotating system is transformed into frictional heat by the relative movement which takes place between the first and the second element 9, 10 respectively at the contact area 12. The damping characteristics  
30 of the damping device can be influenced by adjusting the radial position of the stop 13 or by changing the elastical elements 11 to elastical elements having another stiffness. Sufficient damping characteristic is normally determined by the oscillations occurring upon passage of the first critical number of the  
35 revolutions. The necessary pre-stress of the elastical elements 11

- then gives a contact pressure, which permanently acts in the contact area 12. By the fact that the contact surface 12 is located at least partly in oil, the friction coefficient in the contact area 12 is kept constant at a low level since the creation of coke on the contact surfaces is prevented. The generation of frictional heat in the contact surface, which mainly takes place upon normal operation at operating number of revolutions, hereby can be kept low and constant.
- 10 In the preferred embodiment of the invention shown in the figures, the transfer of the heat generated in the contact area 12 to the bearing becomes especially small by the fact that the device 15 is designed with a radially inner wall, which extends upwards into a downwards open recess 17 in the first element 9. The recess 17 in the first element 9 between the contact area 12 and the bearing 6 results in a decrease of the cross-sectional area of the heat conducting material in a part of the first element, whereby the heat conduction from the contact area 12 to the bearing 6 decreases. The wall 18 forms a screen against heat radiation radially inwards from the part of the first element located in the bowl 14 towards the bearing 6. The heat transfer towards the bearing 6 of the generated heat amount is also decreased by the increased dissipation of heat, which is achieved by the flow of cooling medium through the gap 20 and the passage 19.

- Even though it is preferred that the described bowl, which shall contain oil, is formed by parts of the frame 4, it is quite possible that, instead, it is formed by parts of the first or the second element 9, 10 respectively, within the scope of the present invention.

Claims

1. Centrifugal separator, the rotor (1) of which is supported and is rotatable by means of a during operation oscillating vertical shaft (2), which is rotatably supported in a frame (4) by means of at least one bearing (6) arranged in a non-rotatable bearing housing (7), which is arranged to bear against the frame (4) via a device (8) damping the oscillating movements of the shaft (2) and comprising at least one first element (9) arranged to follow the oscillating movements of the shaft, at least one non-rotatable second element (10) arranged movable relative to the frame (4) towards the first element (9) and at least one elastical element (11) arranged to press the second element (10) radially inwards against the first element (9) to create friction in a contact area (12) between the first and the second element (9, 10) upon oscillation of the shaft, means (21) being arranged to bring oil to circulate around the damping device, characterized by a device (15) forming a bowl (14), which has an upwards directed opening (16) and is so located at the first and second element (9, 10) that at least a part of said contact area (12) is located in the bowl (14).
2. Centrifugal separator according to claim 1, characterized in that said device (15) is formed by a part of the frame (4), a part of said first element (9) extending through the opening (16) into the bowl (14).
3. Centrifugal separator according to claim 1 or 2, characterized in that said first element (9) is formed by a part of the bearing housing (7), which surrounds the rotational axis of the rotor (1).
4. Centrifugal separator according to any of the preceding claims, characterized in that the bowl (14) is annular and surrounds the rotational axis of the rotor (1).

5. Centrifugal separator according to claim 4, c h a r a c -  
t e r i z e d i n that one of the first and the second  
element (9, 10) extends downwards into the bowl (14) with a  
part, which is annular and surrounds the rotational axis of the  
5 rotor (1).

6. Centrifugal separator according to any of the preceding  
claims, c h a r a c t e r i z e d i n that said device  
(15) comprises a radially inner wall (18), which extends upwards  
10 into a downwards open recess (17) in said first element (9) and  
forms a screen against heat radiation radially inwards from the  
contact area (12) between the first and the second element (10)  
towards the bearing housing, the recess being arranged to  
decrease the cross-sectional area of the heat conducting  
15 material.

7. Centrifugal separator according to claim 6, c h a r a c -  
t e r i z e d i n that the first element (9) is formed by a  
part of the bearing housing (7) and has at least one passage  
20 (19), which extends axially through the element (9) and is  
arranged to connect its upper side to its lower side, the wall  
(18) together with the first element (9) forming a gap (20),  
which is arranged to transport a cooling medium through the same  
and the passage (19).

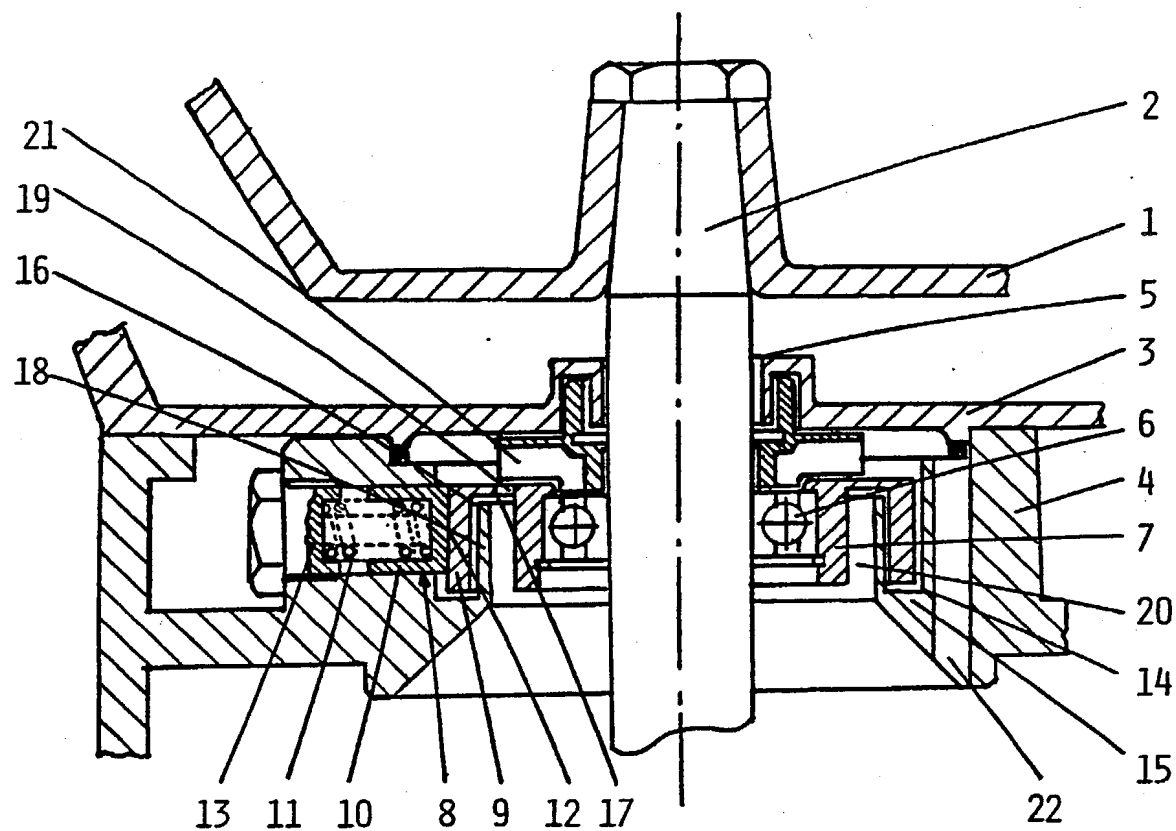


FIG. 1

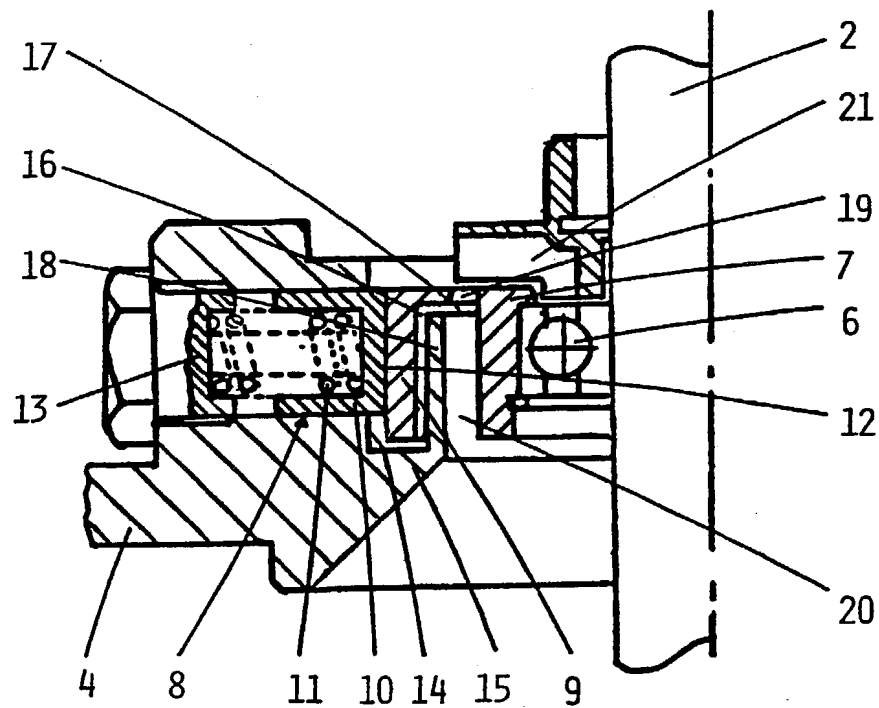


FIG. 2

# INTERNATIONAL SEARCH REPORT

International Application No PCT/SE89/00259

<b>CLASSIFICATION OF SUBJECT MATTER</b> (if several classification symbols apply, indicate all) *	
According to International Patent Classification (IPC) or to both National Classification and IPC	
B 04 B 9/12, F 16 C 27/06	
<b>II. FIELDS SEARCHED</b>	
Minimum Documentation Searched *	
Classification System	Classification Symbols
IPC 4	B 04 B 9/00-/14; F 16 C 27/00,/04,/06; F 16 N 7/12,/32
US C1	233:1, 23; 494:1-85; 184:6.26
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched *	
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III. DOCUMENTS CONSIDERED TO BE RELEVANT *		
Category *	Citation of Document, ** with indication, where appropriate, of the relevant passages **	Relevant to Claim No. **
A	CH, A, 141 617 (RAMESOHL & SCHMIDT AKTIENGESELL-SCHAFT) 16 October 1930	1-7
A	DE, A, 343 420 (RAMESOHL & SCHMIDT AKTIENGESELL-SCHAFT) 1 November 1921	1-7
A	GB, A, 9002 (HERBERT AUSTIN) 5 February 1914	1-7
A	GB, A, 255 437 (MASCHINENFABRIK GREVENBROICH ET AL) 2 July 1926	1-7
A	US, A, 4 556 331 (MUNDE ET AL) 3 December 1985	1-7

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<b>IV. CERTIFICATION</b>	
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
1989-07-25	1989-07-26
International Searching Authority	Signature of Authorized Officer
Swedish Patent Office	Asa Fransson